Small Business Innovation Research/Small Business Tech Transfer

Integrated Launch Vehicle Booster using a Rocket Engine with a Combined Thermodynamic Cycle, Phase I

Completed Technology Project (2018 - 2019)

Project Introduction

The concept describes a booster for a launch vehicle that is simpler to make, transport and launch than current launch vehicles.

It is composed of two major components. The first being a booster structure and the second being a liquid rocket engine that uses a thermodynamic cycle that is a combination of two common cycles.

Furthermore, the engine is actually fairly simple when compared to modern liquid rocket engines, thereby making it less expensive and having more inherently reliably.

The booster uses hydrogen peroxide and kerosene. This is a dense propellant combination that allows the booster to be made out of relatively inexpensive materials yet still have a high propellant mass fraction. This reduces cost.

The booster will use four fixed rocket engines (non-gimballing) that are angled slightly so that pitch, yaw and roll control can be achieved simply by throttling the engines differently. This eliminates the need for a gimbal mount, hydraulic actuators and related componets, flexible propellant feed lines and separate pressure tanks.

Furthermore, with the use of dense, non-cryogenic, hypergolic propellants like hydrogen peroxide, all cryogenic compatible components (which are expensive), insulation and the entire ignition system may be eliminated.

The engine combines a gas generator with an electric pump fed design. It switches from one cycle to the other at the optimum time of flight allowing better performance than an engine using only one of the cycles exclusively. It would use the gas generator mode for liftoff and early in the flight as it can provide high power output at the cost of less specific impulse efficiency. By switching to a closed electric cycle doing boost the engine can then provide higher specific impulse with less thrust, which is acceptable because the booster will have consumed much of its propellant and is lighter.

The combination of this booster and engine allows for a much simpler and reliable launch vehicle.

Anticipated Benefits

NASA could use this vehicle for rapid replenishment of failed satellites. Due to its use of non-toxic, non-cryogenic propellants it can stand by and be available to launch quickly.

Since the system would be cheaper to operate many missions that currently cannot be justified could be possible. For example, sending inspector spacecraft to look at damaged operating satellites is currently not justifiable since building an entirely new spacecraft is more cost effective.

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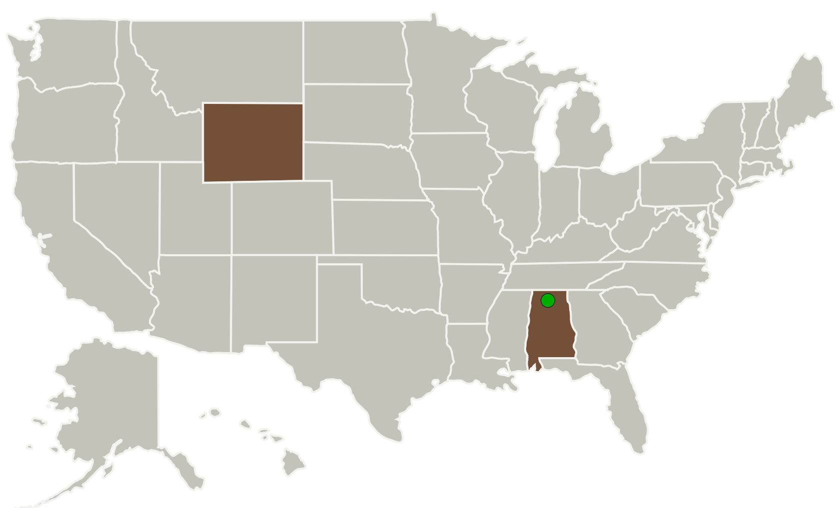
For commercial operators it would both reduce cost and increase reliability. Due to its simplicity it could reduce wait times.

This means that many commercial endeavors, like nano-sats and constellation maintenance, would become potentially profitable. Current launch systems are just too expensive to make these business models work.

It also opens up the possibility of launching new spacecraft to inspect and/or remove dead spacecraft from orbit as an economically viable business model.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Frontier Astronautics	Lead Organization	Industry	Chugwater, Wyoming
Marshall Space Flight Center(MSFC)	Supporting Organization	NASA Center	Huntsville, Alabama

Primary U.S. Work Locations	
Alabama	Wyoming

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Frontier Astronautics

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

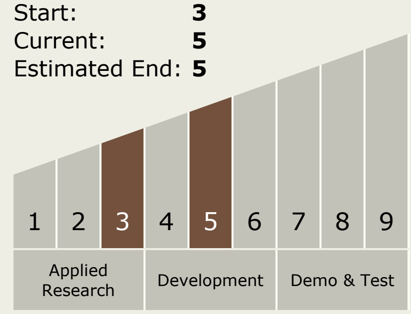
Carlos Torrez

Principal Investigator:

Timothy B Bendel

Technology Maturity (TRL)

Start: **3**
Current: **5**
Estimated End: **5**



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Project Transitions

July 2018: Project Start

February 2019: Closed out

Closeout Documentation:
- Final Summary Chart*(https://techport.nasa.gov/file/141832)*

Images

Briefing Chart Image
Integrated Launch Vehicle Booster using a Rocket Engine with a Combined Thermodynamic Cycle, Phase I
(https://techport.nasa.gov/image/132607)

Final Summary Chart Image
Integrated Launch Vehicle Booster using a Rocket Engine with a Combined Thermodynamic Cycle, Phase I
(https://techport.nasa.gov/image/127335)

Technology Areas

Primary:
- TX01 Propulsion Systems
  - └ TX01.1 Chemical Space Propulsion
    - └ TX01.1.2 Earth Storable

Target Destination
Earth